

## CLAIMS

1. Method for estimating the seismic illumination fold  $I(\bar{x}, \bar{p})$  in the migrated 3D domain at at least one image point  $\bar{x}$ , for at least one dip of vector  $\bar{p}$ ,

wherein the illumination fold  $I(\bar{x}, \bar{p}; \bar{s}, \bar{r})$  for each (source  $\bar{s}$ , receiver  $\bar{r}$ ) pair in the seismic survey is estimated, by applying the following steps:

- determination of the reflection travel time  $t_r(\bar{x}_r, (\bar{p}); \bar{s}, \bar{r})$  from the source  $\bar{s}$  to the specular reflection point  $\bar{x}_r$  on the plane reflector passing through the image point  $\bar{x}$  and perpendicular to the dip vector  $\bar{p}$  and then returning to the reflector  $\bar{r}$ ;

starting from the diffraction travel time  $t_d(\bar{x}; \bar{s}, \bar{r})$  from the source  $\bar{s}$  to the said image point  $\bar{x}$  and then returning to the reflector  $\bar{r}$ ;

- incrementing the said illumination fold  $I(\bar{x}, \bar{p}; \bar{s}, \bar{r})$  related to the said (source  $\bar{s}$ , receiver  $\bar{r}$ ) pair as a function of the difference between the diffraction travel time  $t_d(\bar{x}; \bar{s}, \bar{r})$  and the reflection travel time  $t_r(\bar{x}_r, (\bar{p}); \bar{s}, \bar{r})$ .

2. Method according to claim 1, comprising the step of summing each of the said illumination folds  $I(\bar{x}, \bar{p}; \bar{s}, \bar{r})$  related to a (source  $\bar{s}$ , receiver  $\bar{r}$ ) pair so as to determine the total illumination fold  $I(\bar{x}, \bar{p}) = \sum_{\bar{s}, \bar{r}} I(\bar{x}, \bar{p}; \bar{s}, \bar{r})$ .

3. Method according to one of the preceding claims, wherein, during the incrementing step, the illumination fold  $I(\bar{x}, \bar{p}; \bar{s}, \bar{r})$  is incremented using an increment function  $i(t_d, t_r; \bar{s}, \bar{r})$  according to  $I(\bar{x}, \bar{p}) = I(\bar{x}, \bar{p}) + i(t_d, t_r; \bar{s}, \bar{r})$ , the said increment function taking account of the difference

between the diffraction travel time  $t_d(\bar{x}; \bar{s}, \bar{r})$  and the reflection travel time  $t_r(\bar{x}_r(\bar{p}); \bar{s}, \bar{r})$ .

4. Method according to claim 3, wherein the increment function  $i$  is a function of the seismic wavelet  $s(t)$ .

5. Method according to claim 4, wherein the increment function  $i$  is expressed as a function of the derivative of the seismic wavelet  $s(t)$  according to:

$$i(t_d, t_r; \bar{s}, \bar{r}) = s(t_d(\bar{x}; \bar{s}, \bar{r}) - t_r(\bar{x}_r(\bar{p}); \bar{s}, \bar{r}))$$

10 6. Method according to claim 4, wherein the increment function  $i$  is expressed as a function of the derivative  $\bar{s}(t)$  of the seismic wavelet  $s(t)$  with respect to time according to:

$$i(t_d, t_r; \bar{s}, \bar{r}) = t_d(\bar{x}; \bar{s}, \bar{r}) - t_r(\bar{x}_r(\bar{p}); \bar{s}, \bar{r})$$

15 7. Method according to any one of claims 3 to 6, in which an a priori correction  $w(\bar{x}, \bar{s}, \bar{r})$  of the illumination fold is taken into account by migration, comprising the step of incrementing the illumination fold  $I(\bar{x}, \bar{p}; \bar{s}, \bar{r})$  related to a (source  $\bar{s}$ , receiver  $\bar{r}$ ) pair by

20  $i(t_d, t_r; \bar{s}, \bar{r}) \cdot w(\bar{x}; \bar{s}, \bar{r})$ .

8. Method according to any one of the preceding claims, wherein the determination step includes the second order Taylor series development of the diffraction travel time  $t_d(\bar{x}; \bar{s}, \bar{r})$  around the image point  $\bar{x}$ :

$$25 \quad t_d(\bar{x}; \bar{s}, \bar{r}) = t_d(\bar{x}; \bar{s}, \bar{r}) + (\bar{\nabla}_{\bar{x}} t_d(\bar{x}; \bar{s}, \bar{r}))^T \cdot (\bar{x}_r - \bar{x}) + \frac{1}{2} (\bar{x}_r - \bar{x})^T \cdot \Delta_{\bar{x}, \bar{x}} t_d(\bar{x}; \bar{s}, \bar{r}) \cdot (\bar{x}_r - \bar{x})$$

9. Method according to claim 8, wherein the specular reflection point  $\bar{x}_r(\bar{p})$  is determined along the length of the said reflector such that the diffraction travel time

30 at the said specular reflection point  $\bar{x}_r(\bar{p})$  is

stationary, according to the equation:

$$\bar{p}^T \Lambda (\bar{\nabla}_x t_d(\bar{x}; \bar{s}, \bar{r}) + \Delta_{x,x} t_d(\bar{x}; \bar{s}, \bar{r}) \cdot (\bar{x}_r(\bar{p}) - \bar{x})) = 0.$$

10. Method according to any one of claims 8 or 9, wherein the specular reflection point  $\bar{x}_r$  and the reflection travel time  $t_r(\bar{x}_r(\bar{p}); \bar{s}, \bar{r})$  (are determined according to the following expressions:

$$\bar{x}_r(\bar{p}) = \bar{x} - M \cdot F^{-1} \cdot \bar{b}$$

$$t_r(\bar{x}_r(\bar{p}); \bar{s}, \bar{r}) = t_d(\bar{x}; \bar{s}, \bar{r}) - \frac{1}{2} \cdot \bar{b}^T \cdot F^{-1} \cdot \bar{b}$$

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where:

- M is a (3 x 2) matrix described by two vectors extending along the length of the reflector, and therefore perpendicular to the dip vector  $\bar{p}$ ;

15 -  $\bar{b}$  is a (2 x 1) vector of first order derivatives of the diffraction travel time along the reflection plane:  $\bar{b} = M^T \cdot (\bar{\nabla}_x t_d)$ ;

- F is a (2 x 2) matrix of second order derivatives of the diffraction travel time along the reflection plane:  $F = M^T \cdot (\Delta_{x,x} t_d) \cdot M$ .

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11. Method according to any one of the preceding claims, wherein the determination step uses isochronic migration maps  $t_d(\bar{x}; \bar{s}, \bar{r})$  specified for each (source  $\bar{s}$ , receiver  $\bar{r}$ ) pair involved in the migration at each image point  $\bar{x}$  in the migrated 3D domain.

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12. Method according to any one of the preceding claims, wherein the seismic illumination fold  $I(\bar{x}, \bar{p})$  in the migrated 3D domain is estimated during the Kirchhoff summation migration of seismic data recorded during the 3D seismic prospecting.

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13. Method for correction of seismic data amplitudes recorded during 3D seismic prospecting in order to compensate for the effect of non-uniform illumination of sub-soil reflectors, comprising the steps of:

5       - estimating the illumination fold  $I(\bar{x}, \bar{p})$  using the method according to any one of claims 1 to 12,

          - using the inverse  $I^{-1}(\bar{x}, \bar{p})$  of the said ratio as a weighting factor to be applied to each of the said seismic data amplitudes.

10       14. Method for selection of an acquisition geometry among a plurality of acquisition geometries as a function of the target of 3D seismic prospecting, comprising the steps of:

          - determining the illumination fold  $I(\bar{x}, \bar{p})$  by the  
15 method according to any one of claims 1 to 12, for each of the acquisition geometries considered,

          - selecting the acquisition geometry providing the optimum illumination fold as a function of the target.